8. (Amended) A method of producing a separator for a fuel cell configured by molding a complex in which composition ratios are set to 85 to 97 wt.% of graphite powder, and 3 to 15 wt.% of a thermosetting resin, and an average particle diameter of said graphite powder is set to a range of 15 to 125 μm, wherein

A11

said complex is previously cold-molded into a shape similar to a final molded shape at a pressure of 2 to 10 MPa, and

said preliminary molded member is then placed in a mold, and molded into the final shape by applying a pressure of 10 to 100 MPa.

REMARKS

Receipt of the Office Action of February 1, 2002 is gratefully acknowledged

Claims 1-15 were filed with this application and these have been examined and rejected as follows:

1) claims 1-6 as indefinite under 35 USC 112, second paragraph, because it is not clear "what the graphite powder is bonded to" in the phrase "bonding graphite powder by means of a thermosetting resin;"

2) claims 1, 3, 5, 8, 10 and 11 provisionally under 35 USC 102(e) over copending Application No. 09/660,291;

3) claims 1, 3, 4, 7 and 8 under 35 USC 102(f) because "the applicant did not invent the claimed subject matter;

4) claims 1, 2, 6-9 and 14 under 35 USC 102(e) by Saito et al;

5) claims1, 2, 5-9 and 11-15 under 35 USC 102 (e) over Saito et al;

6) claims 1, 2, 5-9 and 11-15 under 35 USC 102(e) over Braun et al;

7) claims 3, 4 and 10 as unpatentable under 35 USC 103(a) over Braun in view of Uemura et al;

8) claims 1, 3, 5, 8, 10 and 11 as "directed to the same invention as that of claims 7-8 of commonly assigned 09/660,291;

9) claims 1, 3, 5, 8, 10 and 11 provisionally under the judicially created doctrine of obviousness-type double patenting over claims 7 and 8 of copending Application No. 09/660,291; and

10) claims 1 and 6 provisionally under the judicially created doctrine of obviousness-type double patent over claims 1and 7 of copending Application No. 09/685, 093 in view of Saito et al or Braun et al.

These rejections are respectfully traversed.

Regarding 1), note that the graphite powder and the thermosetting resin are uniformly mixed (page 14, lines 22-24 of the specification). The resin is used as a matrix material, i.e., a binder in order to produce strong shaped bodies. There should be no indefiniteness on this point, and accordingly, 1) above has been rendered moot.

Claims 1 and 8 have been amended to recite that the complex is previously cold-molded at a pressure range of 2 to 10 MPa, and the resultant molded member is then molded at a pressure range of 10 to 100 MPa. Claim 8 has been amended so that it too defines the comparable features in method format.

These amendments render rejections 4), 5), 6) , 7), 8) and 9) moot since these limiatations are not to be found in the references relied upon for these rejections.

Regarding 2), it is noted that the noted copending application has the same filing

date as the present application. Therefore, application of 35 USC 102(e) is not appropriate.

Regarding 3), the application of 35 USC 102(f) is not understood, as there is no basis for assuming that applicant did not "invent the subject matter sought to be patented." If this rejection is maintained, clarification is requested.

The present invention relates to a separator for a solid polymer (electrolyte) type fuel cell, used for an electric vehicle, and also to a method of producing the separator.

In fuel cells for electric vehicles it becomes important to provide a small fuel cell because space is limited. Still, the fuel cell must be stable. The separator of the fuel cell necessarily becomes complicated, wherein ribs serving as passages for supplying fuel gases and oxidant gases and gas holes serving as manifolds for making the fuel gases or the like communicate with the passages are formed on its surface.

Also, materials for the separator, a complex of carbon and thermosetting resin, are important. In order to improve the electrical features of the cell, it is necessary to set a compound amount of resin to an extremely small amount. In such a complex, the fluidity inside a mold during formation is less than satisfactory. In other words, if the overall shape of the final molded member is not a flat sheet, the difference in homogeneity and density of the different parts becomes great. So a problem arises, wherein owing to the differences, scattering occurs in the heat-conductivity, electrical features and mechanical features of the different parts.

Though the molded member possesses restorative forces wherein the molded member, which is subject to stress relaxation to some degree after it is molded, exhibits restorative forces, these restorative forces also serve a scattering effect, thereby adverselt affecting the finally molded part. Moreover, when the molding accuracy is adversely affected the

height of each rib, which serve as passages, is not uniform, and when cells are stacked, the contact area which should serve to contact an adjacent cell is decreased, thereby decreasing the electrical features of the cell.

According to the present invention, these disadvantages are overcome using the preliminary molding technique under a predetermined pressure range making thereby a preliminary molded member, and thereafter a main molded process is applied under a higher pressure range. As a result, the complex extends to every corner of the mold, thereby eliminating molding unevenness, while the molded member is dense and homogenous. Consequently, a distance between graphite particles in the resin can be uniformly minimized, while conductivity is improved.

The surface of the preliminary molded member as an intermediate product has the same density in portions where ribs are formed and portions where ribs are not formed. Moreover, the density is homogeneous to a certain degree, and it is strengthened. However, when the ribs are formed from the preliminary molded member in the next step, i.e., the main molding process, the connecting strength between the rib portions and the peripheral surfaces thereof can be increased, because these were the same continuous surfaces having the same density when they formed the preliminary molded members, and the strength of the rib itself is also enhanced to a certain degree. In this way the problem of tearing off of ribs from there root portions is dramatically reduced when the separators are pulled from the mold and when they are stacked.

Ribs are formed from continuous surfaces of the preliminary molded member whose density and strength are improved. So that even if the ribs formed by the main molding

process, density scattering at the top surface and side surfaces of the ribs can be controlled. As a result, the present invention makes it possible to control restoration scattering after molding, caused by density scattering. This prevents height unevenness as well as unevenness in other dimensions. The ribs are more uniform and better controlled.

No mention of any of this capability can be found in Saito et al, Braun et al or Uemura et al

In view of the foregoing, reconsideration and re-examination are respectfully requested and claims 1-5 and 8-10 found allowable.

Respectfully submitted,

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MARKED-UP COPY OF PAGE 2 OF SPECIFICATION

$$--H_2 \rightarrow 2H^- + 2e^- \quad (1)$$

$$(½)O_2 + 2H^- + 2e^- \rightarrow H_2O \quad (2)$$

occur, and, in the whole of the cell, an electrochemical reaction indicated by the formula:

$$H_2 + (½)O_2 \rightarrow H_2O \quad (3)$$

proceeds. The chemical energy of the fuel is directly converted into [an] electrical energy, with the result that the cell can exert <u>a</u> predetermined performance.

A separator for a fuel cell of the solid polymer electrolyte type or the phosphoric acid type that is a kind of fuel cell in which such energy conversion is conducted is [requested to be] <u>desirably</u> gas-impermeable, and also [to be] <u>is</u> made of an electrically conductive material. As a material meeting the requirements, conventionally, an electrically conductive resin is used. An electrically conductive resin is a complex which is configured by bonding graphite (carbon) powder by means of a thermosetting resin such as phenol resin, or a so-called bondcarbon (resin-bonded carbon) compound. A separator for a fuel cell is configured by forming such a bondcarbon compound into a predetermined shape.

Conventionally, a separator for a fuel cell having a predetermined shape is formed by using such a bondcarbon compound in the following manner. With respect to the composition ratio of a thermosetting resin such as phenol resin and graphite powder, 25 to 40 wt.% of the thermosetting resin is--

MARKED-UP COPY OF LAST PARAGRAPH ON PAGE 3 OF SPECIFICATION

--In order to improve the conductivity of a separator for a fuel cell which is configured by using a bondcarbon compound, it [may be] is contemplated that the content of a thermosetting resin [is] be reduced as far as possible, and graphite powder of excellent crystallinity and having less impurities such as ash is selectively used. When the content of a thermosetting resin is reduced, however, elongation and fluidity of the bondcarbon compound during a molding process are lowered, and [the] moldability is impaired. In order to improve the conductivity of a separator, furthermore, it is required to use graphite powder of excellent crystallinity. However, graphite powder of excellent crystallinity is usually poor in wettability and bondability to a resin. When graphite powder of excellent crystallinity is used, therefore, a larger resin content is required. As a result, a uniform separator is obtained more hardly as the resin content is smaller.--

MARKED-UP COPY OF FIRST, SECOND AND THIRD PARAGRAPHS ON PAGE 5 OF SPECIFICATION

--tion to provide a separator for a fuel cell which can be formed into a uniform and predetermined shape while [a] good conductivity is ensured by reducing the resin content so as to suppress the volume resistivity to 1 x 10^{-2} $\Omega\cdot$cm or lower.--

--It is another object of the invention to provide a method of producing a separator for a fuel cell wherein, even when a molding material in which the resin content is small, and which is therefore low in elongation and fluidity is used, the molding material can extend to every corner of a mold so that the separator having a uniform and correct shape that is free from molding unevenness, and [a] good conductivity can be surely produced.--

--In order to attain the objects, the separator for a fuel cell of the invention is a separator for a fuel cell consisting of a complex which is configured by bonding graphite powder by means of a thermosetting resin, and characterized in that, in the complex, a composition ratio of the graphite powder is set to 85 to 97 wt.%, a composition ratio of the thermosetting resin is set to 3 to 15 wt.%, [and] an average particle diameter of the graphite powder is set to a range of 15 to 125 μm, and the complex is molded at a pressure of 10 to 100 MPa.--

MARKED-UP COPY OF PAGE 6 OF SPECIFICATION

--range of 40 to 100 μm. Preferably, the molding pressure of the complex is set to a range of 20 to 50 MPa.

In order to meet the above-mentioned demands for development, [the inventors of the invention have conducted] intensive studies on a separator for a fuel cell which is configured by using a bondcarbon compound, and finally found that the volume resistivity serving as an element which largely affects the performance of a fuel cell is determined not only by the composition ratios of a resin and graphite powder, but also by the average diameter of the graphite powder, and the molding pressure, and that the size of the average diameter of the graphite powder is closely related not only to the volume resistivity, but also to the fluidity, moldability, and strength of the compound. Based on this finding, the composition ratios of a resin and graphite powder, the average diameter of the graphite powder, and the molding pressure have been respectively set to the above-mentioned ranges, thereby completing the invention.

According to the thus configured invention, as the graphite powder which is the one composition of the complex and which largely affects the volume resistivity, graphite powder in which the average diameter is set to a range of 15 to 125 μm, preferably, 40 to 100 μm is used, the thermosetting resin which is the other composition of the complex, and which largely affects [the] fluidity, [the] modability, and [the]--

MARKED-UP COPY OF SECOND PARAGRAPH ON PAGE 9 OF SPECIFICATION

--In the separator for a fuel cell and the method of producing a separator for a fuel cell according to the invention, particularly, it is preferable to set the molding pressure of the complex to a range of 20 to 50 MPa. The molding pressure, and the mold density and the volume resistivity have the correlation shown in Fig. 5. At a molding pressure in a range of 5 to 10 MPa which is usually used in the conventional art, both the mold density and the volume resistivity fail to reach values which are required in a separator for a fuel cell. By contrast, when the molding pressure is set to a range of 20 to 50 MPa, both the mold density and the volume resistivity are stabilized to substantially constant values. When the molding pressure is set to 20 MPa at the minimum, it is possible to obtain a separator of [a] good conductivity.--

MARKED-UP COPY OF SECOND COMPLETE PARAGRAPH ON PAGE 10 OF SPECIFICATION

--As the graphite powder which is useful in the invention, powder of graphite of any kind, including natural graphite, artificial graphite, carbon black, kish graphite, and expanded graphite may be used. In consideration of conditions such as [the] cost, the kind can be arbitrarily selected. In the case where expanded graphite is used, particularly, a layer structure is formed by expanding the volume of the graphite as a result of heating. When the molding pressure is applied, layers can twine together to be firmly bonded to one another. Therefore, expanded graphite is effective in a complex in which the ratio of a thermosetting resin is to be reduced.--

MARKED-UP COPY OF FOURTH AND FIFTH PARAGRAPHS ON PAGE 11 OF SPECIFICATION

--Fig. 4A is a view illustrating a step of producing the separator, and Fig. 4B is a view illustrating the manner of [the] production; and--

--Fig. 5 is a view showing <u>the</u> correlation between the molding pressure, [and] the volume resistivity and the mold density in the production of a separator <u>according to a second embodiment</u> [in Embodiment 2].--

MARKED-UP COPY OF FIRST PARAGRAPH ON PAGE 12 OF SPECIFICATION

--stack structure in which plural unit cells 5 are stacked and collector plates (not shown) are respectively placed on both [the] ends. Each of the unit cells 5 is configured by: an electrolyte membrane 1 which is an ion exchange membrane made of, for example, a fluororesin; an anode 2 and a cathode 3 which are formed by carbon cloth woven of carbon filaments, carbon paper, or carbon felt, and which sandwich the electrolyte membrane 1 to constitute a gas diffusion electrode having a sandwich structure; and separators 4 which sandwich the sandwich structure.--

MARKED-UP COPY OF FIRST PARAGRAPH ON PAGE 14 OF SPECIFICATION

--mulae (1) and (2) above, in the whole of the fuel cell 20, the electrochemical reaction indicated by the formula (3) proceeds, so that the chemical energy of the fuel is directly converted into [an] electrical energy, with the result that the cell can exert predetermined performance. Because of the characteristics of the electrolyte membrane 1, the fuel cell 20 is operated in a temperature range of about 80 to 100°C, and hence involves heat generation. During operation of the fuel cell 20, therefore, coolant water is supplied from an external coolant water supplying device to the fuel cell 20, and the coolant water is circulated through the coolant water passage, thereby presenting the temperature of the interior of the fuel cell 20 from being raised.--

MARKED-UP COPY OF AMENDED CLAIMS 1 AND 8

1. (Amended) A separator for a fuel cell consisting of a complex which is configured by bonding graphite powder by means of a thermosetting resin, wherein

in said complex, a composition ratio of said graphite powder is set to 85 to 97 w.%, a composition ratio of said thermosetting resin is set to 3 to 15 wt.%,

an average particle diameter of said graphite powder is set to a range of 15 to 125 μm, [and]

said complex is <u>previously cold-</u> molded at a pressure of [10] <u>2</u> to [100] <u>10</u> MPa<u>,</u> <u>and</u>

<u>a preliminary molded member resultantly obtained is molded at a pressure of 10 to 100 MPa</u>.

8. (Amended) A method of producing a separator for a fuel cell configured by molding a complex in which composition ratios are set to 85 to 97 wt.% of graphite powder, and 3 to 15 wt.% of a thermosetting resin, and an average particle diameter of said graphite powder is set to a range of 15 to 125 μm, wherein

said complex is previously cold-molded into a shape similar to a final molded shape <u>at a pressure of 2 to 10 MPa</u>, and

said preliminary molded member is then placed in a mold, and molded into the final shape by applying a pressure of 10 to 100 MPa.